



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification <sup>7</sup> : A61M 16/08</p>	<p>A1</p>	<p>(11) International Publication Number: WO 00/56385</p> <p>(43) International Publication Date: 28 September 2000 (28.09.00)</p>
<p>(21) International Application Number: PCT/US00/07671</p> <p>(22) International Filing Date: 21 March 2000 (21.03.00)</p> <p>(30) Priority Data: 09/273,702 22 March 1999 (22.03.99) US</p> <p>(71) Applicant: HUDSON RESPIRATORY CARE INC. [US/US]; P.O. Box 9020, 27711 Diaz Road, Temecula, CA 92589-9020 (US).</p> <p>(72) Inventors: LOESCHER, Thomas, C.; 17574 Via Quatro Caminos, Rancho Santa Fe, CA 92067 (US). FITZWATER, Dennis; P.O. Box 103, Murrieta, CA 92564 (US).</p> <p>(74) Agent: HUNT, Dale, C.; 16th Floor, 620 Newport Center Drive, Newport Beach, CA 92660 (US).</p>		<p>(81) Designated States: AE, AG, AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), DM, DZ, EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KR (Utility model), KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>
<p>(54) Title: ASYMMETRIC PATIENT ADAPTER FOR VENTILATOR CIRCUITS</p> <p>(57) Abstract</p> <p>A patient adapter for being connected to gas tubing in a ventilator circuit comprises of an inspiratory and an expiratory pipe, the latter having an internal diameter at least about 20% greater than the diameter of the inspiratory pipe. The invention also includes a respirator circuit in which an expiratory limb has an internal diameter at least about 20% greater than the diameter than the inspiratory tubing limb.</p> <div data-bbox="844 1197 1412 2037"> </div>		

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

**ASYMMETRIC PATIENT ADAPTER FOR VENTILATOR CIRCUITS**Background of the Invention

High frequency ventilation (HFV) is widely used in ventilation of premature infants because it operates at substantially lower intrapulmonary pressures as compared to conventional positive-pressure ventilation. HFV administers breathing cycles at above about 120 breaths per minute (2 Hz) and as high 1320 breaths per minute (22 Hz) at very low tidal volumes of between about 5 and about 30 ml. Such low volume and high ventilatory rates dictate the use of ventilator circuits having relatively low energy loss and low internal compliance as compared to circuits used with conventional ventilators and ventilation techniques. At the present, ventilator circuits used in administering high frequency ventilation incorporate inspiratory and expiratory tubing limbs of equal tubing diameter, commonly 10 mm inner diameter (ID). The high frequency ventilator circuits include a patient adapter which is substantially symmetrical, having two small diameter pipes each having an outer diameter (OD) of about 10 mm for connecting the tubing. The pipes intersect with a larger diameter pipe for being connected to an endotracheal or tracheotomy tube. Examples of such circuits are neonatal ventilator circuits manufactured and marketed by Hudson Respiratory Care Inc. and HFV circuits manufactured and marketed by Puritan Bennett.

In the administration of high frequency ventilation, flow dynamics of inspiratory and expiratory gas flows are particularly critical because of the manner in which the gas is injected into the patient airways at very high flow rates for very brief time intervals. Typically, gas in HFV is delivered at flow rates of up to 50 liters per minute, but because the pressure is administered for only a fraction of a second, only a small amount of gas actually arrives at the distal airways. Moreover, the patient exhales at the same time and against the flow of gas, quite unlike conventional ventilation in which the inspiratory and expiratory cycles occur independently and the inspiratory gas flow is terminated as expiration begins. Accordingly, for HFV, it is desirable to minimize the expiratory back pressure. For this purpose, high frequency ventilators often incorporate an expiratory compensation valve. HFV circuits also use small-diameter tubing having reduced compressible volume and internal compliance, and are of substantially reduced length to further minimize the column of air in the circuit against which or through which the patient must exhale.

Summary of the Invention

The present invention is directed to a patient adapter used in a ventilator circuit for connecting gas tubing. The adapter features an expiratory pipe having a diameter which is substantially greater than the diameter of the inspiratory pipe. Internal energy loss of the adapter is minimized by using a relatively small angle of intersection of the inspiratory and expiratory pipes, and also by minimizing the angle at which the patient pipe intersects the junction of the inspiratory and expiratory pipes. The invention includes a new high frequency ventilation circuit incorporating an expiratory tubing limb having a substantially increased diameter as compared to the inspiratory tubing limb. The diameters of the two limbs correspond to the diameters of the patient adapter. More specific features of the invention are set forth in the following detailed description.

### Brief Description of the Drawings

Fig. 1 is top view of the asymmetric patient adapter of the invention;

Fig. 2 is an end view of the adapter of the invention; and

5 Fig. 3 is a top view of a high frequency ventilator circuit of the invention including the asymmetric patient adapter.

### Detailed Description of the Preferred Embodiments

Referring to Figs. 1 and 2, there is illustrated the asymmetric patient adapter 10 of the present invention featuring an inspiratory pipe and an expiratory pipe having different diameters. As shown, inspiratory pipe 14 has an interior circular port 17 of a smaller diameter than the diameter of interior circular port 16 of the expiratory pipe 12. Similarly, the outer diameters of the inspiratory and expiratory pipes are different, corresponding substantially to the same difference as the different internal pipe diameters. Typical pipe wall thicknesses are between about 0.5 mm and about 2 mm although such thicknesses are not critical and depend on the design of the pipe.

15 Both the inspiratory and expiratory pipes extend substantially along respective axes which intersect within the interior of the adapter structure. As shown in Figs. 1 and 2, each of the pipes are substantially cylindrical along their respective lengths. As particularly seen in Fig. 1, the axes of the pipes extend outwardly from one another at an acute angle, preferably of about 10°, to minimize energy loss and back pressure. It is also preferred to incorporate a patient outlet pipe 20 having an angled portion 23 for creating a swivel connection more easily secured to an inlet fitting on an endotracheal or tracheostomy tube. The angle of the angled portion 23 from the axis of the straight portion 21 extending from collar 24 is selected to minimize energy loss and back pressure of gas, during the ventilation cycle. An obtuse angle between the axis of straight portion 21 and angled portion 23 is preferably 60° or less. Patient connector pipe 23 is rotatably secured within collar 24 by a snap fitting or the like, although other equivalent means for forming the rotatable connection between the patient connector pipe and the body of the adapter may be used as understood by those skilled in the art.

25 Temperature and pressure monitoring ports are preferably formed on the adapter for receiving and connecting pressure and temperature sensing components or devices. For this purpose, a pressure monitor port 22 extends from the body of the adapter as does a temperature monitor port 18. However, the device may incorporate only one or neither of these ports, depending on the desired use, and the requirement for monitoring the temperature and/or pressure of the gas passing through the adapter. The position and configuration of these ports, including rotatable elbow connections and the like may be selected by those skilled in the art.

30 The difference between the internal diameter of the expiratory pipe and the inspiratory pipe are such that the expiratory pipe inner diameter (ID) is at least about 20% greater than the ID of the inspiratory pipe. More preferably, the expiratory pipe ID is at least about 30%, and most preferably is about 33% (30%-40%) and up to 2 times greater than the ID of the inspiratory pipe. For a preferred adapter used in HFV, the inner diameter of the inspiratory pipe is

between about 8 mm and about 12 mm and the diameter of the expiratory pipe is between about 12 mm and about 18 mm. With these preferred parameters, the ratio of the inner diameter of the inspiratory pipe to that of the expiratory pipe is between 1:1.20 and about 1:2 and more preferably between 1:1.3 and 1:1.5, respectively. The outer diameters will depend on the specific internal pipe diameter plus the thickness of the pipe wall. Again, wall thicknesses of  
5 between about 0.5 and about 2 mm are used, with about 1 mm being typical. The ends of the outer surface of the pipe may also feature annular ribs for making more secure connections to the tubing secured to the pipe ends.

Fig. 3 illustrates a high frequency respiratory circuit incorporating the adapter 10 illustrated in Figs. 1 and 2. An expiratory limb 25 consists of a length of tubing having one end secured to the end of expiratory pipe 12 of adapter 10, and an inspiratory limb 26 comprising a length tubing secured to the end of inspiratory pipe 14. Any suitable  
10 length of tubing may be used. Typically, neonatal circuits are 48 inches long and may incorporate heating wires for heating the gas along the length of the tubing. As illustrated, a heated wire 28 is installed in inspiratory limb 26 illustrating a single-heated limb's circuit. However, dual-heated limbs circuits may be used. Further, the ventilator circuit may also include one or more water traps, for example, as disclosed in U.S. Patent No. 4,457,305. Of course, the size (diameter) of the hose or tubing used in the circuits will correspond to the diameter of the adapter of the  
15 circuit as previously discussed.

Although the circuit described above is primarily focused on HFV circuits used in neonatal and infant ventilator configurations, the invention is not to be so limited. Accordingly, the asymmetric patient adapter of the invention is suitable for adult ventilator circuits used with mechanical ventilators, or in anesthesia circuits. These as well as other uses and features of the invention will be understood by those skilled in the art.

**WHAT IS CLAIMED IS:**

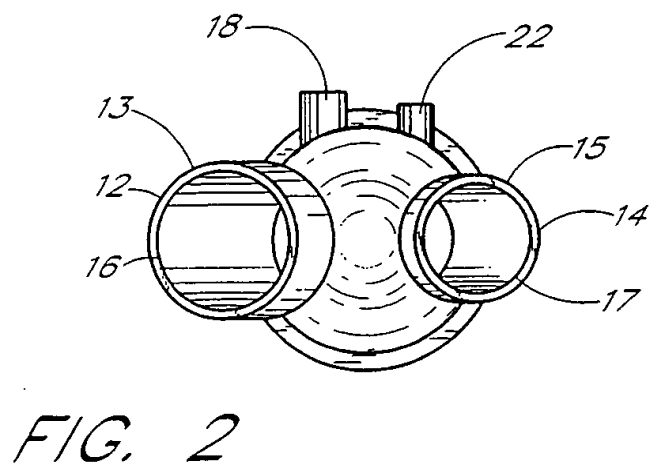
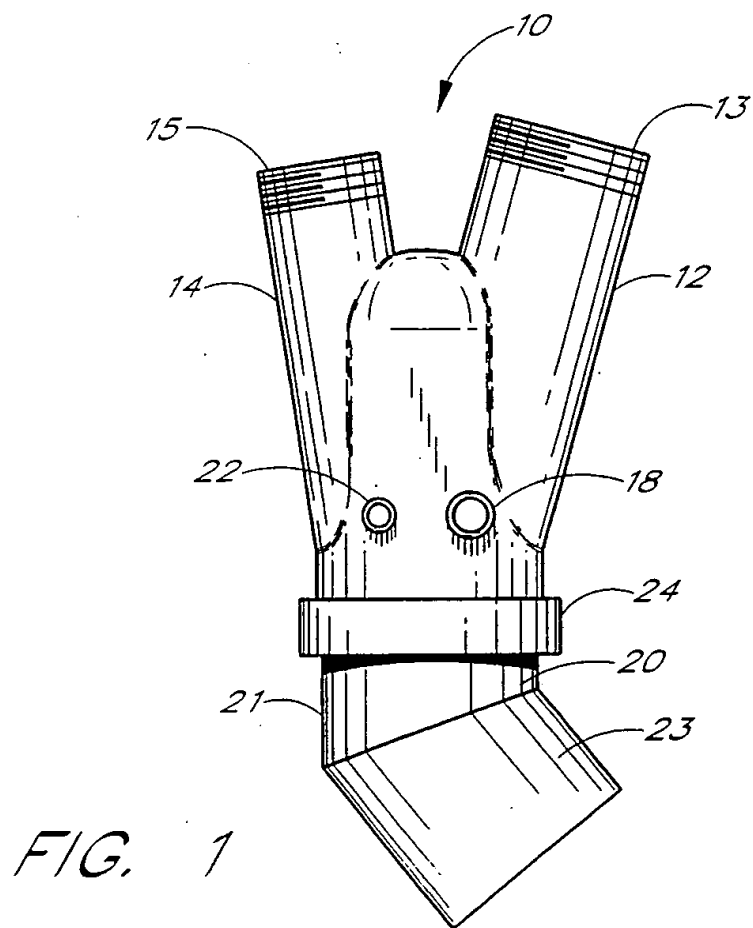
1. A patient adapter for connecting inspiratory and expiratory gas tubing comprising  
an inspiratory pipe having a first internal diameter,  
5 an expiratory pipe having a second internal diameter,  
a patient connector pipe communicating with said inspiratory pipe said expiratory pipe having a  
third internal diameter larger than either of said first or said second internal diameter, and  
wherein said second internal diameter is at least about 20% greater than said first internal  
diameter.
- 10 2. A patient adapter of Claim 1 wherein said inspiratory pipe extends along a first axis and said  
second pipe extends along a second axis and wherein said first and second axes form an acute angle.
3. A patient adapter of Claim 2 wherein said patient connector pipe extends along a third axis  
extending from said first and said second axes.
4. A patient adapter of Claim 3 wherein said first, second and third axes are substantially coplanar.
- 15 5. A patient adapter of Claims 1, 2, 3 or 4, wherein said second internal diameter is at least 30%  
greater than said first internal diameter.
6. A patient adapter of Claims 1, 2, 3 or 4 wherein said patient connector pipe is rotatably secured  
along a third axis.
7. A patient adapter of Claims 1, 2, 3 or 4 including a pressure sensing port.
- 20 8. A patient adapter of Claims 1, 2, 3 or 4 including a temperature sensing port.
9. A patient adapter of Claims 1, 2, 3 or 4 wherein said second internal diameter is about 33% greater  
than said first internal diameter.
10. A patient adapter of Claims 1, 2, 3 or 4 wherein said first internal diameter is between about 8 mm  
and about 12 mm and said second diameter is between about 12 and about 18 mm and wherein the ratio of said first  
25 diameter: second diameter is between about 1:1.3 and about 1:1.5, respectively.
11. A respiratory circuit comprising  
an inspiratory tubing limb including a length of first tubing for directing gas from a source of gas to  
a patient during inspiration,  
an expiratory tubing limb including a length of second tubing for directing gas from a patient during  
30 expiration, and  
an adapter comprising a first pipe having a first internal diameter and connected to said first  
tubing, a second pipe having a second internal diameter at least about 20% larger than said first internal  
diameter and connected to said second length of tubing, and a third pipe having a third internal diameter  
greater than either said first or said second internal diameter.

12. A respiratory circuit of Claim 11 including one or more heating wires extending along at least a portion of said first tubing and/or said second tubing.

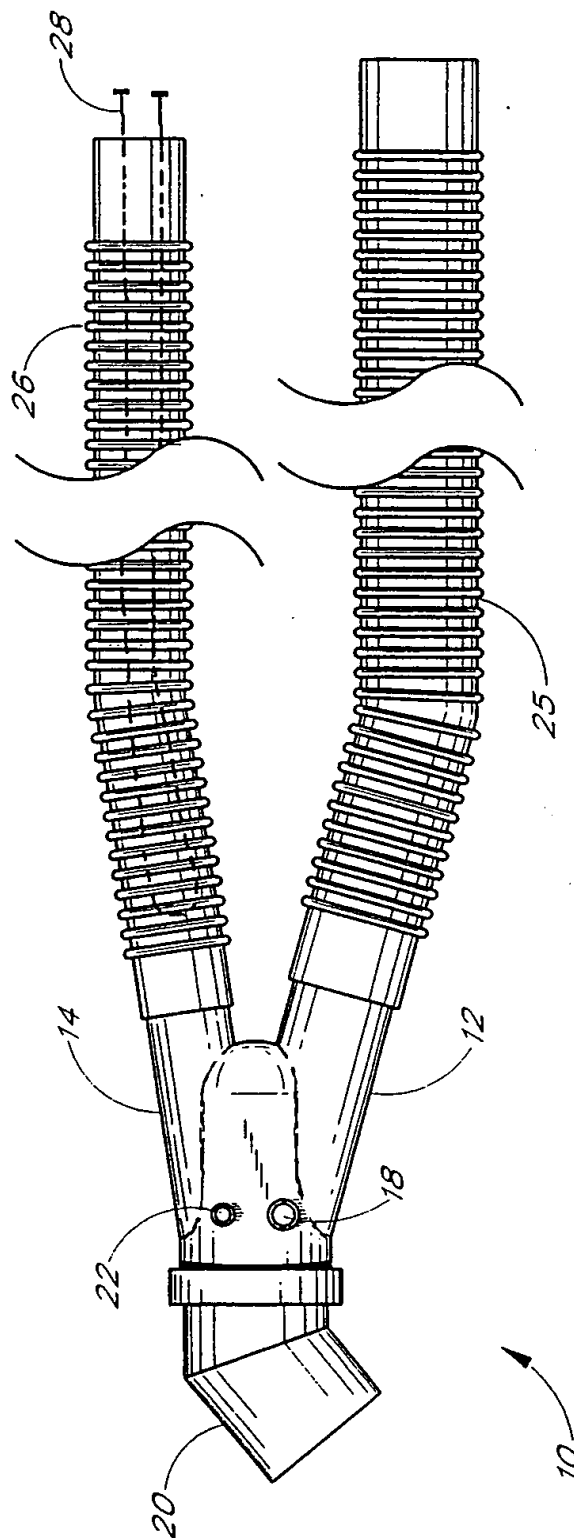
13. A respiratory circuit of Claims 11 or 12 wherein said second internal diameter is 30% to 100% larger than said first internal diameter.

5 14. A respiratory circuit of Claim 11 wherein said first internal diameter is between about 8 mm and about 12 mm and said second diameter is between about 12 and about 18 mm and wherein the ratio of said first diameter: second diameter is between about 1:1.3 and about 1:2, respectively.

10 15. A respiratory circuit of Claim 14 wherein said first tubing has an internal diameter of between about 10 mm and about 15 mm, said second tubing has an internal diameter of between about 12 mm and about 20 mm, and wherein the ratio of the internal diameter of said first tubing : internal diameter of said second tubing is between about 1:1.3 and about 1:1.5, respectively.







## INTERNATIONAL SEARCH REPORT

Int. onal Application No

PCT/US 00/07671

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 A61M16/08

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 A61M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 244 363 A (MOORE JR ROBERT W ET AL) 13 January 1981 (1981-01-13) claim 1; figures	1,11
A	DE 298 23 090 U (SCHMID HERBERT) 4 March 1999 (1999-03-04) page 3, line 31 -page 4, line 20; figure	1,11



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

## \* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*&\* document member of the same patent family

Date of the actual completion of the international search

31 July 2000

Date of mailing of the international search report

04/08/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
 NL - 2280 HV Rijswijk  
 Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
 Fax: (+31-70) 340-3016

Authorized officer

Villeneuve, J-M

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 00/07671

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4244363	A	13-01-1981	NONE	
DE 29823090	U	04-03-1999	NONE	